NAWCWD TM 8565

Tactical Wheeled Vehicle Tire Fire Extinguishing Agent Test Report

by

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FOREWORD

This report describes the results of a survey of commercial off-the-shelf fire extinguishing agents suitable for use against burning tires. The survey was conducted by the Naval Air Warfare Center Weapons Division's Fire Science and Technology Office. It serves to inform acquisition decision makers of options available to them when improving the performance of hand held fire extinguishers against that threat.

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(U) The overall objective of the Tactical Wheeled Vehicle Tire Fire Extinguishing Agent Test series is to provide enhanced fire fighting capability to warfighters. Vehicles suffering from mobility loss due to burning tires require a hand held extinguisher to put out the fire and prevent fire spread past the wheel well. The previously used agent (PKP) was not effective at preventing fire reflash after the fire was out. This report is a 'quick-look' at COTS agents.

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INTRODUCTION

Action during Operation Iraqi Freedom (OIF) revealed a need for an improved firefighting agent that can effectively extinguish a tire fire. All vehicles with rubber tires, especially tactical wheeled vehicles (TWVs), can suffer from a debilitating loss of mobility from a tire fire. Also, TWVs that are fabricated from aluminum (i.e., High Mobility Multi-Wheeled Vehicles (HMMWVs)) are especially susceptible because the aluminum will melt under the assault of the tire fire and allow the fire to quickly spread to the rest of the vehicle.

HMMWVs carry a handheld extinguisher to combat vehicle fires that is charged with five pounds of potassium bicarbonate powder (PKP) agent. PKP does an excellent job of extinguishing the flames of a tire fire, but lacks the ability to prevent reflash. Fully involved tire fires that have been extinguished with even much higher amounts of PKP than is currently carried on HMMWVs will reflash after initial extinguishment, typically within 2 to 10 minutes.

The Naval Air Warfare Center Weapons Division (NAWCWD) Fire Science and Technology Office (FSTO) carried out a 'quick-look' test series to locate commercial off-the-shelf (COTS) agents that may be suitable against tire fires. An evaluation of eight candidate agents was performed against fully-involved tire fires. The results show that tire fires can be extinguished and kept from reflashing using a water-based firefighting agent. The agent must either have a wetting agent in it to reduce the surface tension of the water and allow deep penetration of the agent to the seat of the fire (usually deep in the rubber of the tire), or must have a thickening agent in it to help keep the water in place to provide long-term cooling at or near the seat of the fire.

This report describes the test setup used at NAWCWD, the results of testing, and recommendations, and conclusions. Agents tested were Aqueous Film Forming Foam (AFFF), FireTrol, Barricade, PKP, PKP/Black Widow powder, water/antifreeze, Silvex Foam, and Cease-Fire powder. A description of each agent follows in the next section.

TEST SETUP

Figure 1 shows the typical test setup. A wheel well simulator was fabricated to allow testing to more accurately represent actual conditions in the field. Testing occurred in the NAWCWD burn room in order to eliminate the effect of any ambient wind on the test and allow comparison of agent performance data. Agents under test were placed into a Badger (WP-51) 2 ½ gallon fire extinguisher and the extinguisher was charged with nitrogen to approximately 120 psi.

AFFF (National Foam) is a water-based foaming agent designed to extinguish burning liquid petroleum fuels, currently used by many DOD agencies. FireTrol 931 (Astaris Canada, Ltd.) is a wild land firefighting agent designed to be dropped from aircraft onto forest fires. Barricade (Barricade International) is a water-based agent designed to protect structures from wild land fires by making a thermal barrier on the structure. PKP (Amerex) is a powder agent currently in use by many DOD agencies. Black Widow powder (Fire Trace) is an additive to PKP designed to help remove the heat of the fire and improve PKP performance. Silvex (Ansul) is a Class A foam designed for civil fire department use.

FIGURE 1. Test Setup.

The tire was set on fire using a propane flame originating from a rope burner located under the tire. The rope burner is a section of flexible armored electrical conduit that leaks propane along its entire length. This lighting technique allows a uniform, worst case fire to be developed on the tire. Figure 2 shows the fire extinguisher.

FIGURE 2. Badger Extinguisher.

In order to create the worst case tire fire, the propane was allowed to burn for 6 minutes. At the 6-minute point the tire begins to burn vigorously, reaching a peak in intensity between 11 and 13 minutes. The fire was typically attacked with agent between 11:30 and 12:00 minutes after the start of the fire. The tire was not shredded to simulate fragment penetration, but a hole was placed in the sidewall to prevent sudden rupture.

RESULTS

Several lessons were learned as testing progressed. The first was the importance of sufficient ullage, or gas headspace, in the fire extinguisher. Without enough ullage, the pressure required to push the agent out with sufficient force falls off quickly after initiation of agent flow. Approximately one-fifth of the Badger fire extinguisher's volume was needed as ullage to maintain sufficient agent flow rate. Initially, poor test results with FireTrol agent indicated insufficient ullage. Another lesson learned was the importance of the nozzle design to provide proper dispersion of the agent stream under pressure. Testing with small diameter nozzles did not achieve good results due to low agent flow rate. Poor results with Barricade firefighting agent were due to low agent flow rate. In both cases, good data results were obtained during retesting of each agent after the problems (lack of ullage and improper nozzle selection) were corrected.

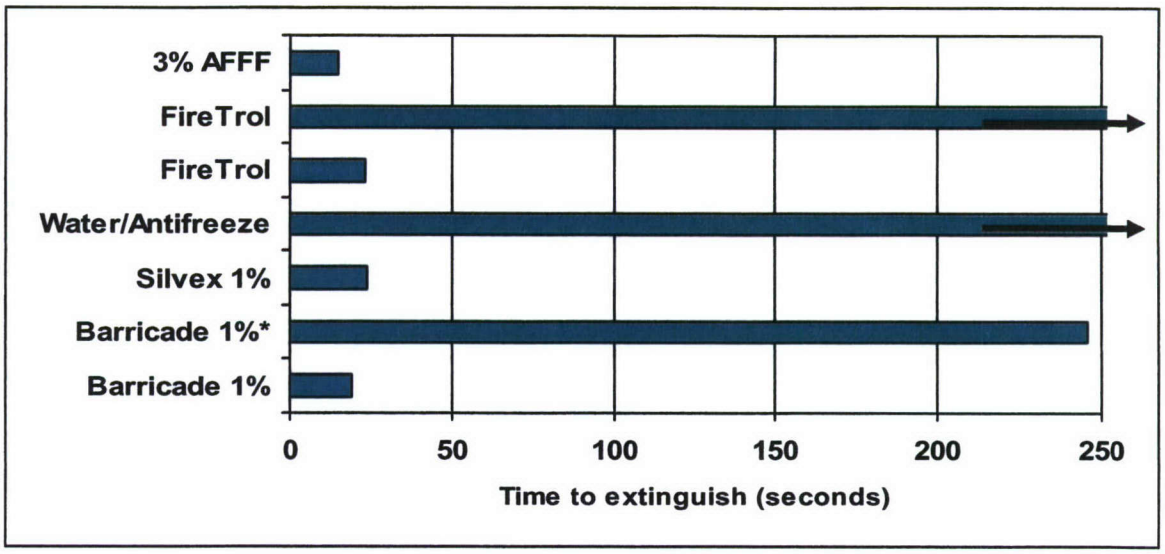

FIGURE 3. Time to Fire Extinguishment by Agent.

Figure 3 shows a graph of the time to extinguishment for each agent. The best performer, in terms of time to extinguishment, was AFFF followed by Barricade, FireTrol, and Silvex. PKP and PKP with Black Widow powder both extinguished the fire very rapidly, but allowed the fire to reflash. Water/antifreeze could not extinguish the fire, neither did Cease-Fire powder. The actual times to fire extinguishment are in Table 1.

TABLE 1. Extinguishment Times.

Agent	Time to extinguish
AFFF (3%)	15 seconds
Barricade (1%) (first trial failed due to improper nozzle)	19 seconds
FireTrol (first trial failed due to insufficient ullage)	23 seconds
Silvex (1%)	24 seconds
PKP with Black Widow powder	3 seconds - reflashed
PKP	6 seconds - reflashed
Water/antifreeze	Did not extinguish
Cease-Fire	Did not extinguish

The amount of water-based agent expended during each test was calculated based upon a typical 45-second full discharge time of the extinguisher when pressurized to 120 psi. The data is presented in Table 2.

TABLE 2. Agent Expended.

Agent	Amount expended
AFFF (3%)	0.83 gal (3,155 cc^3)
Barricade (1%) (first trial failed due to improper nozzle)	1.1 gal (4,164 cc^3)
FireTrol (first trial failed due to insufficient ullage)	1.3 gal (5,047 cc^3)
Silvex (1%)	1.3 gal (5,047 cc^3)
Water/antifreeze	2.5 gal (9,464 cc^3) – did not extinguish

RECOMMENDATIONS

The data in Tables 1 and 2 indicate that AFFF and Barricade were the best performers that also prevented reflash from occurring. From a 2½-gallon container, enough AFFF agent would remain to fight and extinguish two more tire fires (or other burning gear). The Barricade, too, appears to have residual firefighting capacity from a 2½-gallon container to extinguish another tire fire (or other burning gear). Alternatively, a small, lightweight extinguisher that would be easy to handle could be designed to hold "one-tire's worth" of agent. For AFFF, that cylindrical container would measure approximately 12-cm-diameter by 40-cm-tall, and weigh approximately 9 pounds. For Barricade, the container would measure approximately 13-cm-diameter, 45-cm-tall, and weigh 12 pounds.

There are several COTS firefighting agents available that are similar to Barricade. One of these is Arctic Fire Freeze (Global Safety Labs). The Marine Corps Systems Command has purchased 1000 fire extinguishers filled with this agent. We expect these will perform well against tire fires, but have not tested Arctic Fire Freeze to verify its performance.

CONCLUSION

'Quick-look' testing of COTS firefighting agents for use against TWV tire fires conducted by NAWCWD FSTO yielded good results, indicating a viable COTS solution could be acquired by DOD. The acquired agent should be water-based and contain either a wetting agent to reduce surface tension or a thickening agent to make the agent sticky. Not more than 5 liters of agent can be expected to extinguish a fully involved tire fire.

Related research to prevent the spread of a tire fire to the rest of the vehicle is contained in NAWCWD TM 8566, entitled Tactical Wheeled Vehicle Tire Fire Mitigation Study, Interim Report.

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